

Draw **Pharmacology** *in your mind*



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If you are postgraduate and want
to revise pharmacology by an
easy way
If you are using any pharmacology
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لا تنسوني من صالح دعائكم

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VISIT...

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- The largest part of the brain
- Composed of 2 cerebral hemispheres
- The outer layer is cerebral cortex
- **Contains:**
 1. **Motor area** (controls voluntary movements)
 2. **Sensory areas** (control sensation)
 3. **Association areas** (controls higher mental activities such as consciousness, memory, behavior, learning .. etc)

Cerebrum

- Deep in the cerebrum is located the **basal ganglia** which include (**Corpus striatum + Substantia nigra**) (**keep in mind** if damaged → parkinson's disease)

Sensory integrating center

- Receives sensory impulses from all parts of the body and relays them to specific cerebral areas

Thalamus

- Controls **autonomic nervous system functions**

Regulates

1. Body temperature
2. Water balance and metabolism
3. Secretion of anterior pituitary gland

Hypothalamus

Brain

Forebrain

Midbrain

Hindbrain

- **Connects** cerebrum to cerebellum and pons
- Concerned with **motor coordination**

Cerebellum

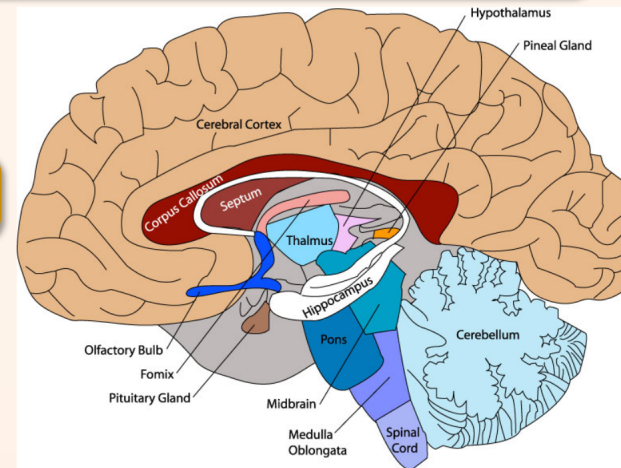
Maintains **body posture and equilibrium**

Pons

- **Connects** cerebellum to medulla oblongata
- Contains **"Locus ceruleus"**

Medulla oblongata

- It is the link between brain and spinal cord
- **Contains many vital centers such as:**
 1. Respiratory center
 2. Cardioinhibitory center (CIC)
 3. Vomiting center (CTZ = Chemoreceptor trigger zone)
 4. Vasomotor center (if inhibited circulatory collapse)



Spinal cord

- Cylindrical mass of nerve cells
- Extended from medulla oblongata to lower lumbar vertebrae
- Passes impulses from and to brain

- Originates from the motor area of the cerebral cortex and passes to the spinal cord so called "corticospinal tract"
- **Regulates fine** voluntary movements

Pyramidal system

- Controls the motor functions but involves areas other than those of the pyramidal system
- **Regulates GROSS** voluntary movements
- **Basal ganglia** is part of this system
- **Keep in mind** .. degenerative changes in the pathway running from substantia nigra to corpus striatum (Nigrostriatal pathway) may cause parkinson's disease (tremors + skeletal muscle rigidity)

Extrapyramidal system

It contains

1. Thalamus
2. Basal ganglia
3. Hippocampus (short-term memory)

- Controls **behavior** and **emotions**

Limbic system

Reticular formation

- Reticular activating system
- Network of nerve fibers and neurons starting from the upper part of the spinal cord and extending upwards to cortex
- It includes **"locus ceruleus"**
- Controls **consciousness** and **wakefulness**

CNS Systems

Tuberohypophyseal system

- Group of neurons running from the hypothalamus to the hypophysis (pituitary gland)
- **Regulates pituitary gland secretion**

- Widely distributed in CNS at cholinergic neurons at: **Motor area - Cerebral cortex - Corpus striatum - Hippocampus - Spinal cord**
- **M₁ receptors** mainly mediate the effect of Ach
- **Keep in mind ..**
If increased at corpus striatum → Parkinson's disease
If decreased at hippocampus → Alzheimer's disease
- **Functions:**
Arousal - Learning - Short-term memory - Motor activity

Acetylcholine (Ach)

Histamine

- Small amounts of histamine are present in CNS
- Its neurons originate from **small regions in hypothalamus**
- Its receptors in CNS: **H₁ , H₂ & H₃**
- **Involved in: Emesis** (so notice that .. most H₁ blockers are associated with antiemetic effects)

Biogenic amines

Noradrenaline (NA)

- Noradrenergic neurons originate mainly at the **pons** from **locus cerulus** and reticular formation
- **High NA in brain** → **wakefulness and alertness**
- **Low NA** → **mental depression**
- **Functions:**
Arousal, Mood and blood pressure regulation

Dopamine (DA)

Serotonin (5-HT)

- Its neurons originate from **Raphe nuclei** (in pons and medulla oblongata)
- Its receptors in CNS: **5-HT₁ , 5-HT₂ & 5-HT₃**
- **Involved in: Mood, Behavioral changes, Hallucination, Sleep/arousal, Sensory transmission control**

Dopamine can act as:

1. **Precursor of NA** at noradrenergic neurons where **dopamine β-hydroxylase enzyme** is present
 2. **Neurotransmitter** in dopaminergic neurons as there is no enzyme
- **Dopaminergic receptors are 2 types: D₁ , D₂** → G-Protein coupled receptors (involve adenylate cyclase / cAMP system)

Dopamine is a neurotransmitter of 3 systems:

1. **Nigrostriatal system (motor function)**
If DA decreased → **Parkinson's disease** (notice that there should be a balance between DA and Ach)
2. **Limbic system (behavior and emotion)**
If DA increased → **Shizophrenia**
3. **Tuberohypophyseal system (endocrine function)**
If DA ↑ → **Growth hormone** secretion ↑ → **prolactin hormone** secretion ↓ (from pituitary gland)

Notes

- **Upon treatment of schizophrenia** (by decreasing the action of dopamine) → Parkinson's- like symptoms will occur (as DA will be < Ach)
- Also DA or dopaminergic agonist stimulates CTZ in medulla oblongata causing **nausea and vomiting**
so, dopaminergic antagonists as **metoclopramide (Primpran®)** can be used as antiemetics



CNS Neurotransmitters

Inhibitory

Aminoacids

Excitatory

Glycine

- Present in high concentration in **Spinal cord**
- Its receptors can be competitively blocked by **strychnine** → **convulsions**
- **Tetanus toxin** can prevent Glycine release → **Violent muscle spasm, sardonic smile**

GABA

- The **major inhibitory neurotransmitter** in the mammalian CNS
- Present only in **brain tissue** (abundant in Nigrostriatal pathway)
- **Synthesized biochemically from glutamate by glutamate decarboxylase**
- **Receptors: GABA_A , GABA_B**

GABA_A

- Channel-linked receptor
- **Mechanism:** if stimulated by GABA → Cl⁻ permeability increase → hyperpolarization → **sedation and hypnosis**
- **The receptor has 3 sites:**
 1. **GABA binding site**
• **Stimulated by** endogenous GABA and GABA agonists
 2. **Modulatory site (Benzodiazepine binding site)**
• **Blocked by** GABA antagonists ex. Bicucullin
 3. **Cl⁻ channel**
• if blocked → convulsions → ex. Picrotoxin
- if activated → CNS inhibition → ex. Alcohol

GABA_B

- G-Protein coupled receptors
- **Mechanism:** Activation of GABA_B → closes Ca²⁺ channels and opens K⁺ channels → inhibition → **skeletal muscle relaxation**
- They can be **selectively stimulated by** GABA_B agonists ex. Baclofen



Glutamate & Aspartate

- **Receptors:**
 1. **Ionotropic** (channel-linked) (**NMDA receptors**)
 2. **Metapotropic** (G-protein coupled receptors)
- When glutamate ↑↑↑ → ↑↑↑ electrical activity → **epilepsy**
- When brain O₂ ↓ → glutamate level ↑↑↑ → excessive NMDA receptor activation → ↑↑↑ electrical activity which may kill brain neurons in some regions **Excitotoxicity** (brain cell death)

Others

Adenosine

- **Receptors:**
A₁, A₂ & A₃ (G-protein coupled)
- It is an **inhibitory** neurotransmitter
- **Actions:** Drowsiness, Analgesia
- **A₂ antagonist** → **Caffeine** → **Arousal, Alertness**

Melatonin

- **Synthesized from 5-HT** in the pineal gland
- **Receptor:** G-protein coupled
- **Action:** It regulates "sleep-wake cycle" (circadian rhythm) (Biological clock)
- Its release is synchronized with **darkness**
- **Used to:** control "jet-lag" and to improve performance of night shift workers